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Selections From White Paper on
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Selections From White Paper on Artificial Intelligence in Italy

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[Text]

Introduction

The purpose of this chapter is to offer a summary statistical picture of current AI activity in Italy. The findings presented herein, in terms of aggregates, are for the most part based on the survey carried out by the Polesis s.r.l. companies during the latter months of 1986 and the first months of 1987. These findings were then expanded and checked by the author against other data gathered by him from attendance at symposia, specific interviews, and market surveys, and so will not necessarily coincide with figures the reader may obtain using the charts relative to the survey that are published in the present volume.

Brief History of Italian Artificial Intelligence

The major innovation in the history of Italian data processing has passed before our very eyes almost unnoticed. Since 1970, all of 135 AI teams have been formed in Italy within the area of research, the universities, the software sector, that of data processing hardware, among its first industrial users, and in the tertiary sector.

This growth of diversified interests and of investments—those interviewed indicate an aggregate of 955 technicians comprising the teams and 56 billion lire spent in 1986—is unparalleled by any other innovative phase traversed by the Italian data processing sector, both as to magnitude and shortness of interval. Suffice it to cite the long incubation period that preceded the diffusion of other innovations such as graphics information processing, or, for that matter, the still relatively small number of existing LANs [local area networks]).

These figures require a measure of clarification: Over 70 percent of the technicians comprising the AI teams have been in the sector less than 3 years. Their experience is therefore still in its initial stage, and in many cases their involvement in AI is part-time; thus, the aggregated figure merely indicates the magnitude of the learning process currently under way in the sector. The 56 billion lire of investment comprise the overall 1986 budget of the teams (59 million lire per capita), including labor costs, general expenses and long-term investments. This aggregated figure thus covers situations that are very diverse from one another and nonhomogeneous within themselves: consolidated research laboratories with high investments per capita, together with university institutes and with small company in-house exploratory teams at the other end of the investment scale.

From 1981 onward, however, the field of artificial intelligence appears to have achieved strategic ranking as an objective of the CNR [National Research Council] and the universities, especially those with a longer tradition in data processing, specialized software (AI) firms, hardware sales firms, major software firms, a major segment of big industry, and now, of the front-runners among the medium-sized tertiary and industrial firms, banks, and minor software firms.

Table 4.1. AI Teams - By Year in Which Formed

Year Formed	Number of Teams	Personnel to 1986
1970	3	42
1971	1	11
1974	1	8
1975	3	95
1976	1	10
1977	1	6
1978	1	10
1979	1	4
1980	1	6
1981	6	59
1982	8	60
1983	11	90
1984	31	202
1985	31	201
1986	35	151
Total	**135**	**955**

Table 4.1 above provides a clear indication of this in terms of numbers. For simplicity of analysis, the years marking the start-up of AI teams can be viewed as comprising three successive phases, each having a different profile, as follows:

First phase: 1970-1980. The heroic years of AI research, in which the lack of adequate funding devoted to research was compounded by objectives that later proved unattainable—objectives such as general problem solvers, computerized general translators, etc.

In these 11 years, in fact, the rate of diffusion of AI in Italy was substantially limited to the realm of research. AI teams were formed by 5 CNR institutes, 6 university institutes, and only 1 industrial group and 1 software firm. Research was oriented towards understanding natural language, voice recognition, and the first systems for computerizing the demonstration of theorems and for computerizing the solution of problems.

On the whole, the total at the end of 1986 shows that approximately 10 percent of the teams—which today, however, absorb 20 percent of the human resources and 8 percent of the investments in AI—were formed during this phase. These findings provide an initial corroboration of the importance of the learning process in accumulating technological knowledge in the field of AI.

Second phase: 1981-1983. The beginning of the 1980's marks the first innovative concrete applications of AI, with: The advent of the first expert systems applied to spectrographic analysis and medical diagnosis; the operational use of image-processing applications; and the advent in the United States of the first LISP machines, special-purpose systems in which, to date, American leadership remains absolute. To this day, there is not a single European producer in this field.

In Italy during these 3 years the number of newly-formed AI teams nearly doubled that of the 11 preceding years: 25 teams versus 13, with 22 percent of the resources and 35 percent of the investments. This phase saw the first innovative opening up of the industrial segment: The forming of their own AI teams by 7 software firms; the advent of 2 new special-purpose AI firms; and projects launched by 2 industrial groups and 3 group research centers; while, in the research field itself, 7 university institutes and 2 CNR research centers continued the process of diffusion that characterized the first phase.

This was the learning phase with respect to the new knowledge-processing technologies emanating from the United States—the phase of greatly increased interest on the part of the specialized-trade, and of the international press in general, in the first industrial applications of expert systems; and the inception of a marketplace offering in LISP machines, special-purpose software, shells, etc for the design and construction of expert systems. In 1982, the highly publicized launching by the Japanese MITI [Ministry of Industry and Foreign Trade] of its fifth-generation computers program stimulated curiosity and industrial policy activity throughout the industrialized world.

Third Phase: 1984-1986. These 3 years saw the birth of 97 AI teams, more in number than the total for the preceding years, with 58 percent of the human resources involved and 56.6 percent of the investments. Looking towards 1987, there are some 50 organizations that have not yet started up their own laboratories but that, to various extents, have already decided to commit resources to the field of AI or are exploring the possibility of doing so.

As can be seen, this third phase also marks a qualitative leap in innovational diffusion, with a shift in the indexation of new entries away from the research institutions (totaling 16 between CNR and universities) towards the industrial groups (26), software firms (25), AI firms (6), industrial group research centers (6), and banks (6). The same shift is evident among the undecideds, with 14 industrial groups and 18 medium-sized software firms that are still in a wait-and-see phase pending a real takeoff of the market for expert-system applications.

In practical terms, 1984-1986 marks the deployment of the international offering of components, with the entry of such data processing giants into the sector as IBM, Sperry, Xerox, Digital, Texas Instruments, Hewlett Packard, etc, which, in effect, legitimated the applications of this technology. The figures we will cite later herein will make clear the role played by these big groups in the emerging user-sector, in Italy as well. In this phase, the learning and research initiatives undertaken by the Italian firms, and in particular by the industrial R&D centers and the medium-sized software firms, attained a first operational milestone under Esprit, which is by far the major European diffuser of industrial AI—initiative that stimulated also the university and CNR institutions to enlarge and concretize their research programs.

Stage of Advancement

For a first cut at trying to assess the stage of advancement of AI in Italy, it was necessary to create a synthetic indicator of the level of technological and applicative advancement of the various existing teams.

To do this, five qualitative classes were defined on the basis of the variables exhibited by the various organizations, i.e., universities, CNR, public-sector laboratories, industrial groups, private-sector group laboratories, software firms and AI firms, data processing companies, consulting firms, banks and local governmental bodies. The variables considered were: Investments in terms of human resources and funds; number of projects in progress and carried through to completion; greater or lesser operativeness of project objectives; and the team's AI experience. The resulting five classes were:

Class A:
—Large industrial AI laboratories;
—AI teams with systems in operation;
—Well-endowed research centers (university, CNR, public-sector);

Class B:
—Research laboratories or industrial laboratories with defined and funded structures and programs;
—AI teams with projects and objectives of an operative nature;

Class C:
—AI teams in a start-up phase;

Class D:
—Organizations with already-defined plans and investments for entry into the field of AI;

Class E:
—Organizations that have decided on future investments in AI but that are still marking time at an exploratory stage.

This initial classification can be used as a basis for evaluating the state of advancement of AI technology in Italy.

Table 4.2. AI Teams - By State of Advancement

Class	Number of teams	Total number of Persons	Personnel %	Median number of persons per team	1986 Spending (Million Lire)	Spending % 1987	Average spent per team (Million Lire)	Average spending per person (Million Lire)
Class A	26	295	30.8	11.35	23,540	42	905.38	79.8
Class B	56	452	47.4	8.07	24,185	43	431.88	53.5
Class C	53	208	21.8	3.92	8,630	15	162.83	41.5
Operative Team Totals	135	955	—	7	56,355	—	417.4	59.0
Class D	14	—	—	—	—	—	—	—
Class E	43	—	—	—	—	—	—	—
Sum Total	**192**							

Table 4.2 above shows that Class A consists of approximately 13 percent of the existing teams, which, however, absorb 31 percent of the human resources and 41 percent [as published] of the investments. In other words, approximately one third of the employees in the AI sector in Italy are engaged in applicative projects of an operative type or in research at a stage that can be termed international state of the art.

The figures are seemingly not very high, but considering the relative newness of AI in Italy they could, on the other hand, be perceived as more than satisfactory. And even more so if one considers that the large majority of Italy's AI teams (109) are in Classes B and C, immediately below Class A, with 69 percent of the human resources and 58 percent of the investments. These findings, in sum, indicate that the AI teams that have come into existence during the past 5 years are fast pursuing operative strategies relative to application of the new technology.

The subdivision of AI teams into these qualitative classes must also take average values into account.

In Class A, the average team size of 11 persons and annual spending of almost 1 billion lire, with a cost-per-worker of around 80 million lire, must obviously be taken as a purely arithmetical average of situations that differ widely from one another. The average cost figures for the universities, for example, are much lower. Nevertheless, these findings appear to attest to the existence already of AI teams in the top category that are well staffed and equipped with advanced facilities for research.

These values drop somewhat in the immediately adjacent classes—to 8 and 4 persons per team, respectively, in Classes B and C—indicating the less-advanced breaking-in stages attained thus far by the teams in these categories. In Classes D and E, these values have no significance, given that these categories consist of organizations that have not yet become operatively committed within the IA sector.

To obtain an idea of the time spans over which these classes were formed, the assigned point-values can be cross-referenced against the start-up years of the teams. This operation shows that the teams formed during the 1970-1980 period are for the most part in the first two classes (4 in Class A and 8 in Class B), whereas of those formed in the second phase, 9 are in Class A (particularly the industrial laboratories), 11 in Class B, and 5 in Class C. The 1984-1986 phase, with the start-up of the AI firms and of the software firm diversifications, yields 13 Class A 37 Class B, and 50 Class C organizations, the latter consisting for the most part of big users.

The distribution of the centers formed during the three phases, among the different classes, suggests that, in addition to the maturation time of the teams, which is obviously relevant, R&D strategies, in terms of defined and operative objectives, and the quantity of resources committed, are also important factors. There appears to be no other explanation for the significant number of Class A centers with pre-operative AI projects in the industrial sector, and of large-scale projects in the research sector, during the time period beginning not more than 5 years ago.

And if one considers the relationships among sectors and teams, listed by classes [Table 4.3], Class A shows a concentration of AI firms, major national electronics laboratories, 2 university centers and 8 large-scale industrial users that already have expert systems in pre-operative applications, and groups with operative plans for additional systems. To be added to these are two firms that already have industrial vision systems designed directly by them and sold on the market.

Table 4.3. AI Teams - By State of Advancement and Sector

Class	Sector	Number of teams	Median number of persons per team
Class A	AI firms	5	7.00
(Competitive teams)	Group research centers	2	15.00
	Public-sector research centers	1	6.00
	Consultant firms	2	5.50
	Industrial groups	8	14.62
	CNR institutes	1	6.00
	University institutes	2	14.00
	Data processing multinationals	2	19.50
	Software firms	3	7.67
Total Class A		**26**	**11.35**
Class B	AI firms	2	7.50
(Established teams)	Banks	2	4.50
	Group research centers	5	7.00
	Public-sector research centers	6	15.17
	Industrial groups	6	6.17
	CNR institutes	5	11.40
	University institutes	13	7.15
	Data processing multinationals	3	4.67
	Software firms	14	7.21
Total Class B		**56**	**8.07**
Class C	AI firms	2	2.00
(Teams activated)	Banks	4	1.75
	Group research centers	2	4.00
	Public-sector research centers	1	4.00
	Holding groups	1	2.00
	Industrial groups	14	4.93
	CNR institutes	4	4.75
	University institutes	10	4.40
	Data processing multinationals	2	2.00
	Software firms	13	3.62
Total Class C		**53**	**3.92**
Class D	Banks	1	
(Teams being formed	Group research centers	1	
	Public-sector research centers	1	
	Consultant firms	1	
	Industrial groups	5	
	University institutes	1	
	Data processing multinationals	1	
	Software firms	3	
Total Class D		**14**	
Class E	Local governmental bodies	2	
(Interested investors)	Banks	6	
	Group research centers	1	
	Public-sector research centers	1	
	Consultant firms	3	
	Holding groups	1	
	Industrial groups	9	
	University institutes	2	

	Data processing multinationals	1
	Software firms	17
Total Class E		43
Sum Total		192

The average ratios given in Table 4.3 above also provide more accurate indicators of the ratios that now characterize the Italian AI sector.

Resources

Table 4.4. Operative AI Team Sizes - By Sector - a/o Yearend 1986

Sector	Number of groups	Number of persons	Investment (Million Lire)	Median number of persons per team	Median investment per team (Million Lire)
AI firms	9	54	4,300	6.00	477.78
Banks	6	16	640	2.67	106.67
Group research centers	9	73	8,100	8.11	900.00
Public-sector research centers	8	101	5,950	12.62	743.75
Consultant firms	2	11	700	5.50	350.00
Holding groups	1	2	50	2.00	50.00
Industrial groups	28	223	16,375	7.96	584.82
CNR institutes	10	82	2,720	8.20	272.00
University institutes	25	165	3,240	6.60	129.60
Data processing multinationals	7	57	3,800	8.14	542.86
Software firms	30	171	10,480	5.70	349.33
Total	**135**	**955**	**56,355**		

Table 4.4 above summarizes the principal economic findings relating to Italian investors in the AI sector. These findings permit the drawing of several conclusions: From the standpoint of overall size of resources devoted to the sector, the industrial groups—mostly by far, as we shall see, those pertaining to large-scale industry—lead all the rest with 223 persons employed in AI, and 16 billion lire spent in 1986 among teams averaging 8 employees per team, at an average expenditure of almost 600 million lire per team.

These figures indicate the marked prevalence of applicative teams already at work—80 percent of them in the field of expert systems—and equipped with tools oriented, generally speaking, towards general-purpose hardware systems. The largest number of AI centers based on minicomputers, personal computers and general-purpose work stations, and low- and medium-cost AI tools, is found among the industrial developers and user groups.

The maximum average investment (almost 1 billion lire with teams of 8 persons) is found in the research centers of private-sector industrial groups—that is, in the R&D laboratories of the big enterprises—where the objective of developing AI innovations necessitates the acquisition of much-higher-cost hardware systems (LISP machines) and software (tools such as Kee, Art, etc).

The same holds true, in part, for research centers in the public sector, where advanced-research objectives require the acquisition of tools and rather sizable investments in capital goods.

Positioned at an intermediate stage of advancement are the software and hardware vendors. In many cases, these firms are still in the process of forming teams and organizational structures, and therefore represent a notable supply potential yet to be expressed in the tools market.

The banking sector, on the other hand, another traditional reservoir of advanced data processing demand in Italy, appears still to be taking its first steps, with a tiny group of investors and resources that evince the inceptive state, as yet, of applicative teams.

At the extreme low end of the values scale are the universities and public-sector research. As to active researchers in the universities, the figures gathered appear lean, with frequently-encountered ratios in the range of 1 to 3 between faculty researchers and doctorate-dissertational researchers on AI topics. This consideration does little to erase the net impression that, with the exception of 3 or 4 well-endowed university centers, this segment suffers from a general lack of available hardware and software resources. In other words, the economic parameters evaluated in the university sector resulted so low as to warrant conclusive affirmation that the diffusion of AI is being left to the initiative of the individual faculty members, and to the somersaults their departments must perform to provide them with a minimum of basic starting facilities, rather than being carried out on the basis of a plan defined at the university or research center level.

Table 4.5. AI Teams - Geographic Distribution by Sectors of Activity

Geographic area	Sector of activity	Number of teams	Total personnel
North	AI firms	8	45
	Banks	4	10
	Group Research Centers	6	57
	Public-sector research centers	4	59
	Consultant firms	2	11
	Industrial groups	23	185
	CNR institutes	4	29
	University institutes	16	104
	Data processing multinationals	6	53
	Software firms	17	106
Total North		**90**	**659**
Central	AI firms	1	9
	Banks	2	6
	Group research centers	3	16
	Public-sector research centers	2	30
	Holding groups	1	2
	Industrial groups	4	34
	CNR institutes	6	53
	University institutes	6	46
	Data processing multinationals	1	4
	Software firms	12	55
Total Central		**38**	**255**
South	Public-sectsor research centers	2	12
	Industrial groups	1	4
	University institutes	3	15
	Software firms	1	10
Total South		**7**	**41**
Sum Total		**135**	**955**

Another critical consideration concerns the territorial distribution of the resources surveyed. Table 4.5 above shows that 67 percent of the teams are found in Northern Italy, versus 28 percent in Central Italy, and only 5 percent in Southern Italy. If one considers human resources and capital goods investments, the contrast favors the Mezzogiorno even less: 4.3 percent and 4.7 percent respectively. The industrial AI teams, which as we have seen tend in large part to gravitate around big industry, also tend to reside in their respective group headquarters and group R&D laboratories. The result is a geographical concentration towards the North rather than one proportional to the distribution of productive structures.

Table 4.5 further reflects the prevalence of public-sector-based AI teams in the Mezzogiorno: 3 university institutes, 2 public-sector research centers, 1 software firm, and only 1 industrial group (in its initial applicative stage)—truly a scanty situation as compared to the more

balanced distribution in Central Italy, whose cornerstone regions around Pisa and Rome represent AI concentrations comparable to those around Milan, Turin and Genoa. And the situation does not seem headed for change via a spontaneous dynamic of its own, at least over the short term. In fact, considering only the Class D and E agencies, which represent the potential, the percentages veer even further away from the South, except for a relatively greater interest on the part of the universities.

Another relevant basis of differentiation with respect to teams and resources is economic size (Table 4.6).

Table 4.6. AI Teams - By Economic Size and Sector

Sector	Size	Number of teams	Total personnel
AI firms	Small	9	54
Banks	Large	4	12
	Medium	1	2
	Small	1	2
Group research centers	Large	8	69
	Medium	1	4
Public-sector research centers	Large	6	91
	Medium	2	10
Consultant firms	Large	1	8
	Small	1	3
Holding groups	Medium	1	2
Industrial groups	Large	23	115
	Medium	4	105
	Small	1	3
CNR institutes	Large	8	59
	Medium	2	23
University institutes	Large	3	39
	Medium	21	125
	Small	1	1
Data processing multinationals	Large	3	45
	Medium	4	12
Software firms	Large	8	46
	Medium	55	
	Small	16	70
Total		**135**	**955**

Given the appreciable lack of homogeneity among teams, it was considered preferable to disaggregate this variable by sectors. Thus, the following analysis was obtained:

Potential demand: An absolute prevalence of large-sized businesses is noted among the users (industrial groups, banks, local government entities), even though, from the standpoint of the distribution of human resources, the difference is in part mitigated by the existence of a large number of semi-affiliates of large groups operating in high-technology sectors—automation, telecommunications, electronics, etc—and acting somewhat as applicative ground-breakers for their respective groups. In any case, as in other countries as well (United States, France, etc), the applied-AI learning process appears at this time to be spearheaded by the large enterprises, which are, after all, the only ones that have the financial and technological resources needed to undertake experimentation with expectations of return on investment often in the medium- to long-term range.

Software offering: On the supply side of the software market—medium-sized software firms, specialized AI

applications firms, etc—the picture is inverted. As regards both AI firms—that is, all the small-sized companies formed during these years by specialized teams of AI technology experts—and software firms, the preponderance of small units is considerable: 22 medium- and small-sized software firms versus 8 large-sized firms.

This finding, however, must not mislead: True, in the field of AI—as in all leading-edge technologies still in the art stage—the barriers to entry for an initial positioning within the sector appear to be rather low, but it is also unquestionable that a ratio of 49 to 34 between firms offering applications and industrial groups and banks using them represents more than one potential offerer of technologies per user of record as of today.

In other words, as in all the initial phases of a relatively accessible and promising technology, there is a relative piling-up of firms stating their industrial interest in supplying the new market versus a core of effective demand that is still limited to the major industrial groups. Thus, the scenarios can range between two extremes: Either the demand will expand spontaneously over the next 2 to 3 years to meet these emerging supply plans, or a forthcoming skimming of the AI offering in the software and AI firms sector will take place. A real industrial applications market for AI still does not exist in Italy (nor for that matter abroad). Thus, there still is room for the emergence of recognized primary supply operators who, above all—through realizations demonstrably capable also of impacting the sphere of medium- and small-sized businesses—can expand the demand beyond the confines characterizing the experimentation being done by big industry.

From the standpoint of number of investors and commitment of resources, the banking and insurance sphere appears to be still at a substantially wait-and-see stage, as are also the governmental and tertiary sectors.

Research: In the field of research, insofar as concerns R&D centers in the private and public sectors, large size still predominates. Here too, it would appear that the entrance barrier should be scalable. And in fact, the recorded sizes of Italian AI research teams do not average over 3 persons per project. But there are factors in this field that appear relevant, such as: A concentration effect and threshold of experience; cultural resources; plans; facilities (above all, costly LISP machines and vision systems); and investment capital for documentation and for visits abroad. Nevertheless, considerable generic interest in AI research is evident on the part of Italian university institutes: The past 3 years have seen the forming of initial AI teams in many venues distinct from the established research hubs of the major metropolises. And this process has frequently had its inception at the bottom, in the form of an initiative, not infrequently of an interdisciplinary nature, on the part of faculty teams or even individual members of the faculty.

Human capital and technical tools: Of 955 technicians devoted to applications or research in the field of AI, almost half (45 percent) claim less than 2 years of experience in the sector, 27 percent list claim 3-4 years, and the remaining 28 percent over 4 years. Are these figures credible? According to other surveys (A. D. Little, 1985), the number of Italian researchers with over 4 years of experience in the field is a far lesser one: 50 faculty members and 20-30 industrial technicians. On the other hand, the figures are based on the statements of the persons interviewed, who probably tend to overestimate their own internal resources or to credit many retrained technicians with retroactive seniority. The aggregated figure, considerably higher than expected, is nevertheless interesting as is the consideration that 70-80 percent of the Italian AI technicians have operated in this field for such a limited number of years as to suggest a learning phase in full swing.

A second consideration must be borne in mind with regard to these aggregate figures: They combine, for example, technicians who in less than 2 years have acquired real industrial experience relating to expert systems and vision systems with exploratory personnel assigned by firms to an initial evaluation of the sector. And, in the field of research, they combine researchers who in the last 2 years have taken courses in foreign universities with academic teams that are only now beginning their first experiments on the new frontier.

The most firmly established teams are to be found in the pioneering university research centers and in the AI firms. In the industrial sphere, the average length of experience of the researchers is lower, and is at a minimum in the software firms and in the banks, where the AI technicians are for the most part explorers.

As of the end of 1986, the research tools installed and in use in AI laboratories totaled: 64 LISP machines, 94 minicomputers, 103 work stations, 43 mainframe computers, and 360 personal computers. Except for the LISP machines and most of the work stations and personal computers, the existence of general-purpose systems in the responses as regards tools attests to resources often shared with other areas in the research laboratories, this being typical in the case of minicomputers, or even in that of in-house computational centers (especially as regards mainframe systems). Shared facilities are the general rule during the initial phases of the AI team (exploratory stages).

So as to present a rational picture of existing software and hardware in research centers, however, aggregates were compiled on the basis of AI laboratory configurations, under 6 headings which, together, cover the totality of the centers.

The 6 configurations are:

- A: Centers based on LISP machines (Symbolics, LMI, etc), hybrid tools (Kee, Art, Knowledge Craft);

- B: Centers based on work stations (Sun, Apollo, Microvax, etc) and hybrid tools;
- C: Centers based on work stations and simple software tools (shells, environments, traditional and/or special-purpose languages, etc);
- D: Centers based on minicomputers (Vax, Eclipse, etc) with simple tools;
- E: Centers based on mainframe computers equipped with simple tools;
- F: Centers based on personal computers supplemented by simple tools.

Table 4.7 shows such a distribution compiled according to the foregoing configurations.

Table 4.7. AI Teams - By Hardware, Software Resources and Sectors

Configuration	Sector	Number of Teams	Investment (Million Lire)
Class A (LISP machines, hybrid tools)	AI firms	1	2,000
	Group research centers	3	4,500
	Public-sector research centers	6	5,650
	Consultant firms	1	500
	Industrial groups	7	5,380
	CNR institutes	3	1,500
	University institutes	7	1,520
	Data processing multinationals	4	3,500
	Software firms	3	1,100
Total Class A		**35**	**25,650**
Class B (Work stations, hybrid tools)	AI firms	3	1,300
	Group research centers	1	1,000
	Public-sector research centers	1	100
	Industrial groups	2	1,100
	University institutes	2	130
	Software firms	2	400
Total class B		**11**	**4,030**
Class C (Work stations, simple tools)	Group research centers	3	2,500
	Industrial groups	3	760
	CNR institutes	2	200
	University institutes	6	820
	Data processing multinationals	3	300
	Software firms	9	5,100
Total class C		**26**	**9,680**
Class D (Minicomputers, simple tools)	AI firms	1	500
	Group research centers	1	50
	Public-sector research centers	1	200
	Industrial groups	9	7,840
	CNR institutes	3	470
	University institutes	5	555
	Software Firms	10	1,920
Total class D		**30**	**11,535**
Class E (Mainframe computers, simple tools)	Banks	4	540
	Holding groups	1	50
	Industrial groups	3	1,100
	CNR institutes	1	450
	Software firms	3	1,700
Total class E		**12**	**3,840**

Table 4.7. AI Teams - By Hardware, Software Resources and Sectors

Configuration	Sector	Number of Teams	Investment (Million Lire)
Class F	AI firms	4	500
(Personal computers,	Banks	2	100
simple tools)	Group research centers	1	50
	Consultant firms	1	200
	Industrial groups	4	195
	CNR institutes	1	100
	University institutes	5	215
	Software firms	3	260
Total class F		**21**	**1,620**
Sum total		**135**	**56,355**

A total of 26 percent of the teams, representing 45 percent of the investments, have available a center based on LISP machines and hybrid tools. Class A covers 7 university institutes, 7 industrial groups, 6 public-sector research centers, 3 private-sector centers (but with maximum unitary investments in that category), and 4 data processing manufacturers. Software and AI firms are automatically excluded from Class A by the sheer magnitude of the necessary resources: Further evidence of the barrier to advanced research and experimentation, which these firms have not yet overcome—or rather which, as we shall see later herein, they are seeking to circumvent.

The number of centers in Class B (11 in all) is limited; but the presence of 3 AI firms indicates that this class, which is less costly than one above but just as effective, featuring powerful work stations and hybrid tools, and, for that matter, of very recent design—it is only in the last few months that items such as Kee and Art tools have become part of standard work stations—is destined to grow in forthcoming months and is already finding considerable favor among specialists like the members of the new AI firms.

Class C is typical of sectors in which the existing tools are less standardized (as, for example, research in the natural language, vision, and image processing fields) and, in general, sectors tending more towards pure and exploratory research (hence, the relatively large number of university institutes), plus a nucleus of software firms equipped with work stations (Microvax and Unix) on which, moreover,the software for the entire firm is developed.

Class D typifies two operator typologies: On the one hand, those who work in the field of vision systems, in which the prevailing class consists of a minicomputer and dedicated tools, and in that of industrial automation; and on the other hand, the agencies that have only recently formed AI teams and are using the hardware facilities that already exist in the laboratories. The responses from the operators polled reflect a decided trend towards a future transition to Classs C and B.

Class E identifies with, above all, the banking and insurance sector—enterprises, that is, that are beginning to explore applications capable of integration with their usual data processing environment based on mainframe computers—a segment of the market that is still unstable, given the scarcity of efficient AI tools in the general-purpose-mainframe environment.

And Class F exhibits a net polarization between, on the one hand, a nucleus consisting principally of AI firms and university institutes that has based its AI strategy on personal computers, and that also has human resources with considerable experience; and on the other hand, the group consisting of industries and software firms that is at the initial-prototype and learning stage, and that has therefore chosen the personal computer as an exploratory tool.

Technological Areas and Projects

To begin with, the fact warrants stating that the field of expert systems predominates, by a large margin, over the other sectors of applied AI: 126 centers out of 135 have projects completed or in progress in this area, while only 9 laboratories or firms operate exclusively in the sectors of natural language processing (2) and artificial vision (7). In 23 (principally research) laboratories, research is carried on in several fields.

To analyze the Italian AI applicational research map, 13 fields were defined, whose frequency obviously introduces multiple responses (Table 4.8)

From the above figures it follows that approximately 60 percent of Italian AI research (expert systems) is being done in the field of industrial automation. In fact, those operating in this area are: 23 industrial-user groups, many of the private-sector (7) and public-sector (5) research centers, and a sizable number of AI firms (4) and software firms (11). Relatively minor is the interest

Table 4.8. AI Teams - By Applications Fields

Field	Number of Teams	Percentage of Total Number of Teams
Artificial Intelligence:		
Expert systems	126	93.33
Natural language	34	25.18
AI tools	26	19.26
Vision systems	19	14.07
Voice	8	5.92
Expert Systems:		
Industrial automation	67	49.63
Managerial and professional	53	39.26
Financial	18	13.33
Data processing center automation	10	7.40
Telecommunications	8	5.92
Military	7	5.18
Education	18	13.33
Medicine	19	14.07

being shown by the university institutes (9), among which, however, are some of the best-endowed entities, and by the CNR centers (1). The interest being shown in the sector by the data processing firms (7) is also considerable.

In the management-and-professional field, the most numerous category is that comprised of software firms (19), followed by AI firms, while the financial sector is dominated by the banks (6) and software firms. The field of expert systems for data processing is comprised of 3 software firms and 2 data processing enterprises.

The military field is dominated by the industrial groups (7).

The educational expert systems sector, which is relatively well-off in terms of operators, with respect to the recent evolution of AI in this sense, shows a prevalence of public-sector and university research institutes. The medical field as well is served by at least 7 university institutes and altogether 6 CNR and public-sector institutes.

The rather diffused activity in the field of natural language processing exhibits a decided prevalence of research agencies (altogether 13 including CNR, university and other centers) versus a small number of software firms (3) and 4 private-sector laboratories. The field nevertheless already exhibits a fairly well-defined industrial orientation, especially in terms of industrial projects calling for natural language interfaces to data bases.

A total of 8 groups operate in the field of voice processing: 2 data processing firms, 2 major laboratories connected with the telecommunications sector, 1 CNR laboratory, and 3 of Italy's best-endowed university institutes. The voice- and speech-processing sector is, after all, one that still appears to be distant from attaining extensive application on an industrial basis.

The industrial supply component (9 agencies) in the vision systems field is equal in number to the research agency component, but more oriented towards image processing. Operators in this field also include importers of systems, who do not do research but only marketing and installation.

A surprisingly large number of agencies (26) work on projects that have as a near-term or long-term objective the production of tools. In this compartment, Italian primacy is contested between the major laboratories of the software firms and those of the telecommunications field, while a significant number of software and AI firms (8) appear interested in the sector. The CNR laboratories (5) have also set as goals, medium-term in most cases, the development of marketable tools in the research fields (natural language, image processing, advanced languages, etc).

The university institutes (21) represent half the operators in the area of basic research, orthogonally overlapping the cited applicational fields, while the other half is distributed among public-sector agencies and private-sector group laboratories.

A further disaggregation of the Italian AI map is provided by a detailed analysis of the activities of the groups by technological areas. The 20 fields considered in the treatment which follows do not perfectly coincide with the applicational map, in that the expert system typologies (diagnostic systems, for instance) may refer to either the industrial applicational field or the medical one. In large part, however, the two maps tend to coincide, as can be seen from Table 4.9.

Table 4.9. Technological Areas

Area	Number of Teams	Supply	Research	End Use
Expert Systems:				
Diagnostics	52	38	42	19
Layout	17	35	29	36
Planning	26	42	23	35
Monitoring	14	28	29	43
Design	19	32	37	31
Decisional support	53	42	28	30
Education	14	28	28	34
Natural Language:				
Interfaces with data bases	24	25	63	11
Comprehension	17	12	88	0
Vision Systems	19	16	68	26
Tools:				
For personal computers	11	55	36	9
Other	16	50	43	7

Note that Table 4.9 provides a first break-out of the technological distribution of the activities of the 135 IA teams operating in Italy. Distribution by teams was preferred over distribution by projects—602 projects in all, including completed ones as well as those in progress—as being more indicative of the technological lines being pursued by the workers in the sector.

A disaggregation by projects would have produced a distribution of some 100 technological areas, but since, as a rule, the AI teams pursue a plurality of projects in diverse technological areas, and since many research centers are engaged in basic research projects quite devoid of homogeneity with industrial ones, it was preferred to base our analysis on the frequencies of a few key areas of AI application and research in Italy. These frequencies are to be read as indices of diffusion and interest in each specific field.

Table 4.9 permits us to roughly define 5 areas of analogous nature. The first comprises the operative industrial expert systems (diagnostic, layout, planning, monitoring, design, decisional support). The interest of more than half the teams is concentrated in this area, together with the maximum participation of suppliers (software and AI firms, makers of data processing hardware, consultants) and of demand (industrial groups and banks).

In the field of diagnosis (the largest in absolute terms), the presence of research institutes—42 percent of the interested centers, including public- and private-sector laboratories, university institutes and CNR centers—is explained by the exigencies of the medical area, which is relatively less crowded with market operators and which is still in need of further research to realize diagnostic expert systems of greater depth and reliability.

Except for the medical area, the field of industrial diagnosis is today perhaps the most stabilized of all the applied AI technological areas. Hence, the presence of a fairly large number of Class A teams, almost all with a completed project of an operative nature or even with systems in a field-testing phase. Layout, monitoring, design and planning all present analogous characteristics: The presence of AI laboratories at work on operative projects, sizable interest on the part of industrial users, and limited participation by the research sector (particularly the public segment) except in the case of institutes that are just beginning to invest in AI with initial projects that are relatively easy and well-funded.

The field of expert systems for decisional support covers a large variety of applicative projects, all, however, having in common the objective of providing assistance to the professional in his or her field of interest. The majority of these systems are designed and/or intended to be used with personal computers. The systems in this part of the spectrum comprise a sizable portion of the offering—or better yet, of the readying—on the part of the software firms, the consultants who are forming AI teams, and the industrial groups making their first moves into the sector.

The second area—expert systems for the legal profession, office automation, occupational and academic training—represents the applicative technological field that, in part, is still unexplored even from the standpoint

of the more stabilized AI techniques. In these fields, the difficulty lies less in the development of new methods of representing knowledge or in other basic problems than in an accurate analysis of the applicative field, thence optimal adaptation of the AI technologies already in existence.

This explains the rather high proportion of research agencies, particularly university institutes, that frequently avail themselves of limited technical resources such as personal computers, while the only fields attracting significant interest are occupational training, on the part of the user sector, and office automation, on that of the data processing hardware suppliers.

The third area is that of natural language and image processing—fields that are absolutely not stabilized as yet but that, in the area of natural interfaces to data bases, are manifesting substantial applicative interest from the standpoint of supply as well as demand, in addition to that of the major AI centers.

The fourth area is tools, in which supplier and research interest are almost equivalent, with a strong presence on the part of major AI centers, especially in the field of advanced tools for LISP machines. This is a strategic field, from the standpoint of being able to greatly increase the diffusion of applications.

The fifth area is that at the cutting edge of R&D. The quasi totality of the major national research centers—particularly, those of the CNR and the major universities—are concentrated in this area, with a rather balanced distribution in the various fields. Noteworthy is the sizable industrial interest in the area of multiple expert systems—that is, expert systems operating jointly on problems that are too complex for a single system—and in parallel hardware, on which much research effort is being concentrated by the private-sector group R&D laboratories, frequently with objectives in terms of future products.

Table 4.10. State of Advancement of AI Projects

Completed Projects	**Number**	**Feasibility Study**	**Demonstration Prototype**	**Operative Prototype**	**Complete System**
Enterprises	101	26	27	19	29
Private-sector laboratories	24	8	7	7	0
Universities	79	12	42	9	16
Public-sector laboratories	26	0	7	6	13
Total	**230**	**46**	**83**	**41**	**58**
Active Projects	**Number**	**Exploratory**		**Operative**	
Enterprises	193	52		141	
Private-sector laboratories	14	4		10	
Universities	110	78		32	
Public-sector laboratories	55	25		30	
Total	**372**	**159**		**213**	

The number of projects recorded totaled 602, of which 230 had been completed and 372 were in progress, with an average of approximately 3 researchers per project. Taken as a whole, the recapitulations shown in Table 4.10 provide a composite picture of the state of learning of the entire Italian AI sector: The total number of completed AI projects is characterized by a prevalence (56 percent) of feasibility studies and demonstration prototypes—typical of the initial phases of team operations—while the area of complete prototypes and complete systems appears concentrated for the most part among the enterprises. It is important to note that the definition of the latter area is to be understood as not including the systems that are in current use today in organizations—totaling not more than 2 or 3 to date in the enterprises—but solely systems complete with respect to every component and already in use in the laboratories or being field-tested. In the universities, most of the experimentation is related to demonstrators and to feasibility studies, hence obviously based on research prototypes, while the public-sector laboratories appear oriented, as do the enterprises, towards projects aimed at operative application.

The area of projects in progress signalizes a further stage in the learning process, or rather in the passage from feasibility demonstrators to more structured and targeted testing. The ratio of operative objectives—213 projects out of 373, or 57 percent—does in fact appear to represent a majority and a rising trend with respect to the past—that is, to completed projects—with enterprises (73 percent of a total of 193 projects being operative ones) and private-sector laboratories (10 out of 14, or 71 percent) clearly predominant, while the universities appear increasingly oriented towards projects of an explorative type (78 projects, or 71 percent, out of a total of 110).

The inference can be drawn that, in the past, the research sector, in the learning phase at the time, has centered its work on projects of relatively lesser complexity from which minor and even complete prototypes have ensued. Today, faced by an industrial sector that is proceeding, with increasing speed, towards operative applications, the universities and the research sector are tending instead to become involved in more sophisticated and cutting-edge fields.

Cooperative Research and the Tertiary Sector Activities

There is a close correlation between company strategic objectives in the field of AI and the starting up of tertiary sector activities. Of 135 centers, in fact, 78 (equal to 58 percent) are engaged or plan to be in occupational training, consulting and technology transfer activities in the sector. These centers include all the AI firms (9), the data processing firms (8), and almost all the software firms, but also approximately half the university institutes, 6 of 10 CNR centers, 6 of 9 private-sector R&D centers, and all the public-sector research centers.

On the other hand, the industrial groups show a scant leaning—only 3 out of 27—towards tertiary activities, these 3 being groups whose objectives include future marketing of their own AI technologies.

All 100 percent of the responses indicated openness to receiving tertiary services, in the form of consultations, agreements, cooperation between agencies, and documentation of various kinds (over 60 percent of the groups subscribe to at least one foreign magazine specializing in AI).

Of 135 groups in all, 85 (equal to 63 percent) participate in at least 1 national or international R&D program (Table 4.11). This is a rather high percentage, which confirms the AI sector's crucial need not only of financial support but also of an interchange of knowledge among researchers on coordinated projects. On the whole, the international projects (Esprit in particular) appear much more oriented than the national ones towards the support of industrial innovation and involvement of those AI centers most closely connected with industrial application and/or best equipped with resources—the fact being that, except in the case of those being funded by the IMI [Italian Credit Institute], which are very few, the percentage of Class A laboratories involved in these projects is systematically higher.

Table 4.11. Participation in National and International R&D Programs

Program	Number of Agencies	Supply	Research	End Use	% of Class A
ESPRIT	37	16	16	5	24
EUREKA	8	1	5	2	25
ESA	6	2	2	2	67
COST	1	0	1	0	0
RACE	0	0	0	0	0
BRAIN	0	0	0	0	0
CNR	26	1	22	3	12
IMI	9	3	3	3	33
MPI	23	1	20	2	17

The national programs, on the other hand, are more oriented towards the support of research, in which relatively few Class A and many Class B laboratories are involved, with a broader-based mechanism for the distribution of funding.

The role of the IMI as an applied research fund and an innovational revolving fund appears to be of entirely too small a scale, particularly as regards its impact on projects whose supply-side import is relevant. The groups benefiting from funding by the IMI are only one fourth of those participating in Esprit, and no particular targeting emerges from the pattern of its interventions, which are about equally distributed as to supply, research and demand. This represents unquestionably a lag in Italian industrial policy that needs to be highlighted and to which we will refer again in our conclusions.

Conclusions

In summary, the findings of this survey seem to substantiate some clearly identifiable trends:

1. From 1983 onwards, Italian data processing, in virtually all its constituent aspects, has set forth on a course of experimentation and learning in the sphere of AI technologies. The tempo of the diffusion process, with over 100 teams at work within the various organizations, appears extremely lively and exceeds the initial expectations of the operators themselves. A fertile terrain exists, therefore, on which it is possible to operate with suitable funding initiatives and incentives.

This consideration, although positive in its outlook, must not, however, be allowed to mislead: The Italian AI gap exists—as has been brought out in other chapters of this volume—and is attested to, for example, by the extremely high proportion of AI researchers and technicians having become such almost as a matter of expediency over the past 3 years.

A human resources problem exists, therefore, and it is a pressing one. According to extrapolations of a very

informal nature, made by the author of this article, by 1990—that is, within not more than 3 years from now—the need for AI technicians with actual experience and industrial training should at least double over the present level, consisting of the 1,000 or so researchers who, as we have seen, are in need of provisions for intensive training. This poses the problem of a training strategy and of imparting a strong stimulus to university education, which is woefully underpowered today if one considers an estimate—made by A.D. Little, 1985—of not more than 50 professors and researchers in AI in Italian universities.

2. A spontaneous trend is clearly visible, moreover, towards the creation of didactic and research areas in AI in the university and research spheres, where an authentic race is under way towards the creation of teams, the starting up of projects, the insertion of the new knowledge technologies into the foregoing activities—a wedding between AI and traditional data processing, in the jargon, and an extremely weak approach. This demand for AI, particularly in the university sphere, appears diffused and horizontal, and spreads throughout many of the didactic centers connected, in various ways, with electronics technology. It appears to be expressing itself, however, through initiatives from the bottom up, substantially external to any didactic and research initiative at the national level.

3. In the industrial world, over the past 4 years, the big manufacturing industries have made substantive moves, with predominantly active end-use objectives. Noteworthy is the prime-mover role undertaken by the major Italian data processing user-schools—that is the big company computing centers with an established tradition and experience. This industrial interest seems mainly concentrated in the area of computerization, and is still at the operational training stage. The first signs of interest on the part of the medium-sized enterprises are also visible, particularly on the part of those operating in the medium-to-high-technology sectors.

This is unquestionably the most significant fact to emerge from the entire study. By way of analogy with other situations abroad—the United States, for example, where the big experimenters in AI are the major industrial groups—the same scenario is taking place in Italy as well. The motives behind this primacy of the big industries in the experimentation process are at least three:

- **The economic factor:** As in the case of all technologies in their emergent phase—suffice it to recall that of the first computers in the 1950's—there is a problem of resources and of medium-to-long-term investment horizons. The first applications researchers therefore tend to be the big organizations, which satisfy these requisites for accessing a field like AI that is highly customization-intensive—each expert system being, in actual practice, specifically made to order—and that carries a high level of risk, in that the technology is still unstable and at its inception.
- **The cultural factor:** AI technology is, in a sense, a kind of "higher level" in the now firmly-established data processing line of succession. It is natural, therefore, that the user organizations with the most experience and extent of application in data processing should represent a far more culturally open and motivated initial applicative terrain than other segments of the demand, especially the small- and medium-sized firms.
- **The applicative factor:** AI technology promises significant advantages, principally on the management front and on that of the further computerization of complex systems. The need for these advantages is particularly felt by big industry, where, today, it is precisely in the area of efficient management of data processing systems integrated on an organization-wide basis that significant competitive advantages tend to be concentrated.

One of the key frontiers in this systemic computerization effort is specifically factory automation. This area is without doubt, on the one hand, big manufacturing industry's principal terrain for advanced experimentation, and on the other hand, the context in which AI applications seem relatively most proven and viable. Suffice it to recall in this regard the expert systems for maintenance and layout. This explains the finding that over 60 percent of the AI projects are related to this area.

4. The banking sector, for its part—another major user-school in the Italian data processing sphere—appears, for the time being, to be still in a wait-and-see and substantially exploratory phase. In this area, the demonstration on an international scale of really successful solutions based on AI have, beyond any doubt—and unlike the automated factory and industrial logistics in their respective area—had a minor effect. It is an area in which experiments that have succeeded abroad—for instance, in the United States—are not borrowable, because of empirical differences between financial markets and between institutional contexts.

Notwithstanding this, the major Italian banks can also be expected to form their own experimentation teams, over the forthcoming months and years, to seek AI solutions in connection with automation of the system and of the services it provides. Very recently, in fact, indications have appeared signaling the start of projects and of interest on the part not only of the big but also of the medium-sized institutes.

On the supply side, three considerations are in order:

—1. In Italy, as in the other industrialized countries, a market already exists for AI tools and services. In 1986, this market was estimated to be around 10-15 billion lire, with growth rates exceeding 50 percent per annum. But there is still no market for solutions and applications. There are still, in fact, no "AI application packages" that the user can simply apply to his particular needs. Solutions require a sizable content of

know-how in AI technologies, provided, as a rule, by consultants abroad, and of user-knowledge relative to the specific field of the desired application.

The AI tools market in Italy, as in the rest of Europe except, in part, Great Britain, is almost entirely one of imports: 100 percent in the case of LISP machines and specialized hardware; 100 percent in that of more or less advanced software tools.

On the other hand, the market for services—consultation, designing of prototypes for third parties, training in the use of tools, etc—is supplied almost entirely by Italian firms, primarily the 9 small AI firms surveyed, which often sell together with their services also the related tools (software and in some cases also hardware) developed domestically or imported.

This succinct description brings into view the risk the nascent Italian AI sector is running: As occurred toward the end of the 1970's in the field of major software systems, which today are almost all being imported, the emerging Italian AI offering's failure to capture the internal market, consisting of not only the Italian but also the European one, could result, in the coming years, in what might be termed in effect a further colonization by potential foreign suppliers, particularly American ones, able to impose their solutions on a market characterized by a low level of applications experience, limited diffusion of stand-alone products, and insufficient value added by Italian applications firms to support effective strategies for attaining international competitiveness.

Hence the need (see also paragraph C below) to implement a demand-growth strategy aimed at enhancing the emergent supply/demand ratio.

—2. Perhaps the most surprising finding of the survey as a whole is the sizable interest being shown in the new technology by the software firms sector and the AI firms being formed in the wake of the new technology. This interest has not been matched, for the time being, by an analogous responsive opening of the medium- and small-sized business segment of the applications market, the segment to which these firms traditionally relate. From the findings of the survey, there emerges also a notable lack of parity between, on the one hand, those who today are setting supply goals and, on the other, existing users. As has been seen, this ratio is greater than 1. It follows that the software firms that are in the process of diversification and innovation will have to create a market in new sectors—the tertiary, medium-sized firms, etc—and that the supply group will tend to break up into firms that little by little will succeed in developing solutions capable of triggering diffusive and imitative processes in the user sector.

—3. A close correlation is noted between the forming of teams, especially in the software firms segment, and public-sector research programs, particularly Esprit. This correlation induces a taking into account of the relative effectiveness of the instruments of industrial policy as a factor in the initialization and diffusion of the new technology. The impact of Esprit on the diffusion of AI training in Italy is evident from the findings. However, this fact must not mislead: A project capable of initializing is one thing; industrial policy projects and measures capable of truly generating and firming up a market are quite another. Specifically the latter appear to be the crucial objective today: Demand-side applicative projects whose relevancy and stability will be effective initializers of a first phase of sector maturity. It is on this terrain that any strategy aimed at attaining international competitiveness and the narrowing of lags in Italian AI's emergent offering must advance.

Assuming the validity of the foregoing considerations, at least three strategic options appear necessary in order to transform this nascent situation into a real strong point of Italian data processing.

- A. As regards short-term educational policy, there appears to be a need, at the university level, for a policy of diffusion of the teaching of AI technologies in the technical colleges, that will support the diffused demand for adaptation of the new technology. The approach of confining AI to the bounds of a few future specialized courses—the need ofwhich in their own right is, of course, abundantly clear—seems diametrically opposed to the finding of diffused interest disclosed by the survey and the future need of human resources. The findings state that, practically speaking, the world of the university appears to feel that the training of all future graduates in electronics and data processing must include knowledge of AI, as an indispensable professional tool in forthcoming years.

- B. With respect to research policy, the strategy could be two-pronged. On the one hand, it could aim to enhance the demand for AI learning that is emanating by diffusion from the universities, by enacting a blue-ribbon policy targeted on the promoting of applied research combining traditional data processing with AI techniques.

Practically speaking, the learning process on the part of the university centers should be supported by a strategy aimed also at reaping effective results from it in terms of technology transfers to the productive sector. And here, the means best suited to the objective would appear to be management of the funding for research allocated by the Ministry of Education.

And on the other hand, for the medium term, it would appear necessary to centralize the more highly specialized training and advanced research, especially with respect to the basic AI technologies, in a few selected blue-ribbon centers, in which resources and brains could be concentrated with a view also to stemming, to the

extent possible, the continuing and dangerous flight of researchers to the United States. Here, the means best suited to the objectives are the CNR Targeted Projects and the specific initiatives by the Ministry of Scientific and Technological Research, which could be provided with the necessary legislative and funding support. From the didactic standpoint, the blue-ribbon centers could be equipped to provide, in the future, not only specific training but also specific graduate courses targeted on the creation of technologies at a more profound depth of specialization.

- C. As regards industrial policy, consideration must be given first of all to the strategic role of demand-side projects on the part of big industry in the next and necessary phase of firming up the emergent Italian AI sector. Hence the need to think in terms of concerted action on major systems, such as telecommunications networks, public and private services, industrial systems engineering, etc, that can bring the potentiality of internal demand to bear on the realizing of successful applicative capabilities—the factor that is most lacking in the field of AI at the world level—and that can trigger the effects of demonstration that are needed to develop the market. The means best suited for the getting under way of these strategic applications projects could be Law 46 with its relative funds, as way of creating the necessary demand, the supply being already profuse.

Another initiative that appears necessary is the one addressed to the Italian industrial automation sector, which over the next several years will necessarily have to be integrated with systems engineering capabilities in the fields of advanced data processing and artificial intelligence. In this regard, a specific automated factory project would be a valid undertaking; or a joint laboratory that would interface the user firms with the specialized firms and the technological resources, even by way of a policy of incentives aimed at interindustrial alliances.

As for the medium term, consideration could be given to extending Law 695—the new law that provides incentives to the acquisition of machine tools and the integration of computer-based products into production subsystems, including also software—to the support of diffusing AI to small- and medium-sized business. With reference still to the medium term, interest appears warranted in the proposal, which has already been advanced by several sources, to establish a research and design laboratory to produce "intelligent modules" for insertion in the traditional products, or new ones, that form the backbone of the Italian productive structure.

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